The Stratigraphic Palynology of the Namoi River Valley, Baan Baa to Boggabri, Northern New South Wales

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The palynostratigraphy of bores sunk for water exploration shows that the alluvial fill is late Miocene-earliest Pliocene and remarkably similar to all the major river valleys of the western slopes. The basement, where encountered, is Stage 5 of the Permian. The vegetation of the Late Tertiary was a mosaic of rainforest with araucarians and sclerophyllous forests with Myrtaceae and/or Casuarinaceae dominant. In latest Pliocene/Pleistocene, the forest became more open.

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INTRODUCTION

Numerous shallow bores have been sunk in the alluvial fill of the valleys of the Western Slopes by the New South Wales Department of Water Resources in the search for ground water.

This paper records the palynology of some of the bores in the Baan Baa-Boggabri region of the Namoi River Valley and its tributary, Coxs Creek (many bores do not yield pollen). The Late Tertiary history of the vegetation is compared with that of other river valleys of the Western Slopes. The age of the pre-Tertiary basement, where encountered, is reported also.

METHODS AND MATERIALS

The samples used in this study are cuttings, as cores were not taken. The possibility of contamination is greater with cuttings than with cores, but with care and appropriate procedures, relatively clean cuttings may be produced. For investigative drilling, from 1.5 to 4.6 m is drilled and then the mud circulated until clean of the coarse fraction. This practice minimises carry-down. Cavings, where sediments higher up may break away from the side of the borehold and be incorporated with cuttings from deeper levels, may be detected by different colours or other properties. While the possibility of contamination in cuttings can never be ruled out, experience has shown that cuttings may produce reliable results. Consistent patterns, repeated in bore after bore, would not be possible with appreciable contamination (Martin, 1993).

Preparation techniques used hydrochloric and hydrofluoric acids to remove the mineral material, controlled oxidation with cold Schultz solution, and potassium carbonate to clear the residues.

GEOLOGY

The valley fill rests on a basement of Permian and Jurassic sandstones, shales, conglomerates, tuff, coal, limestone and volcanics. The older sediments are unconsolidated and frequently cannot be identified apart from the Tertiary fills, without palynological evidence. For location of bores, see Fig. 1.

The alluvium consists of a clays, silts, sands, and occasionally gravels. Only the grey-coloured clays and silts yield pollen.

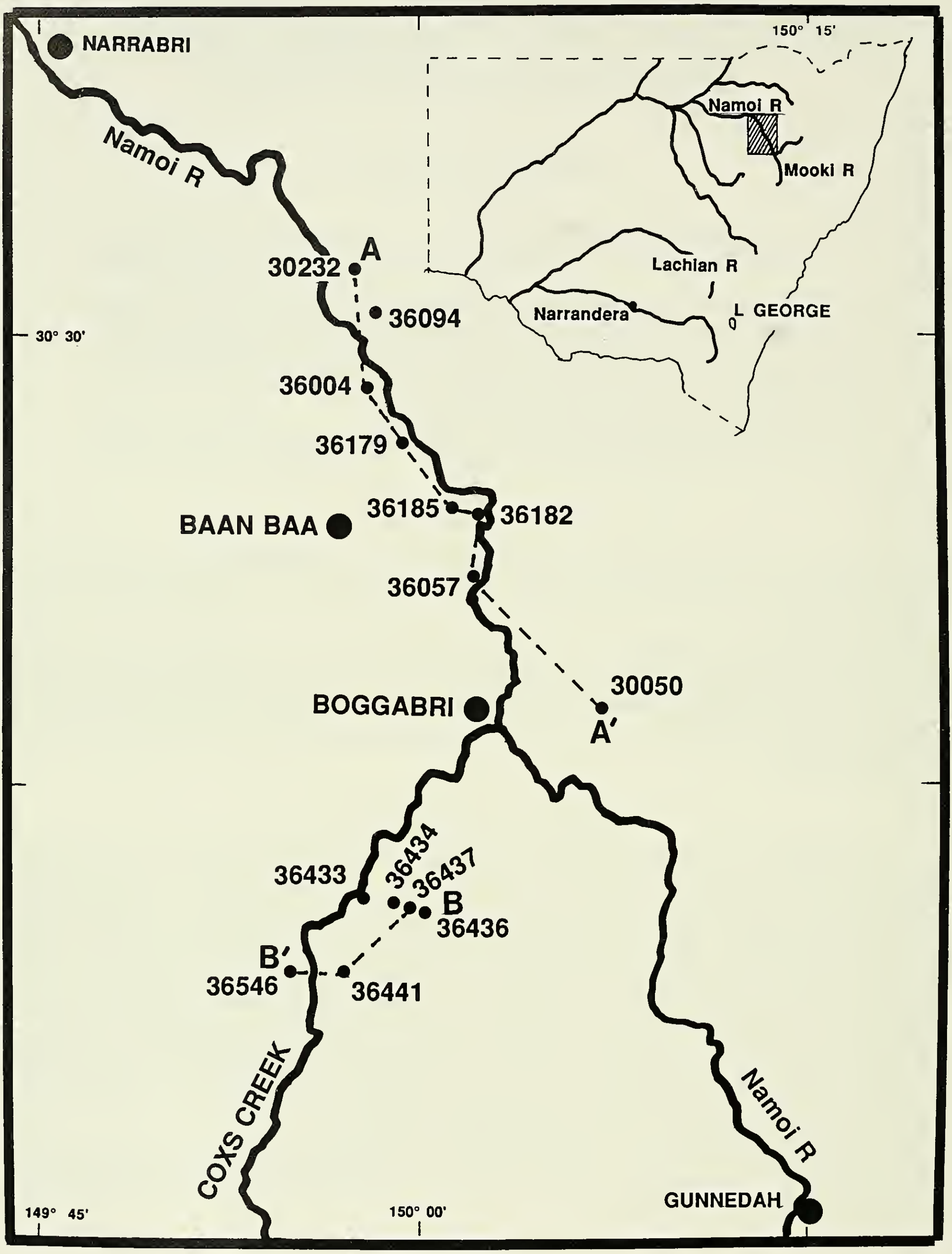

Fig. 1. Locality map.

Palynostratigraphy

Permian

Permian basement was encountered in some bores. Table 1 presents the species identified and Fig. 2 shows the stratigraphic ranges of diagnostic species.

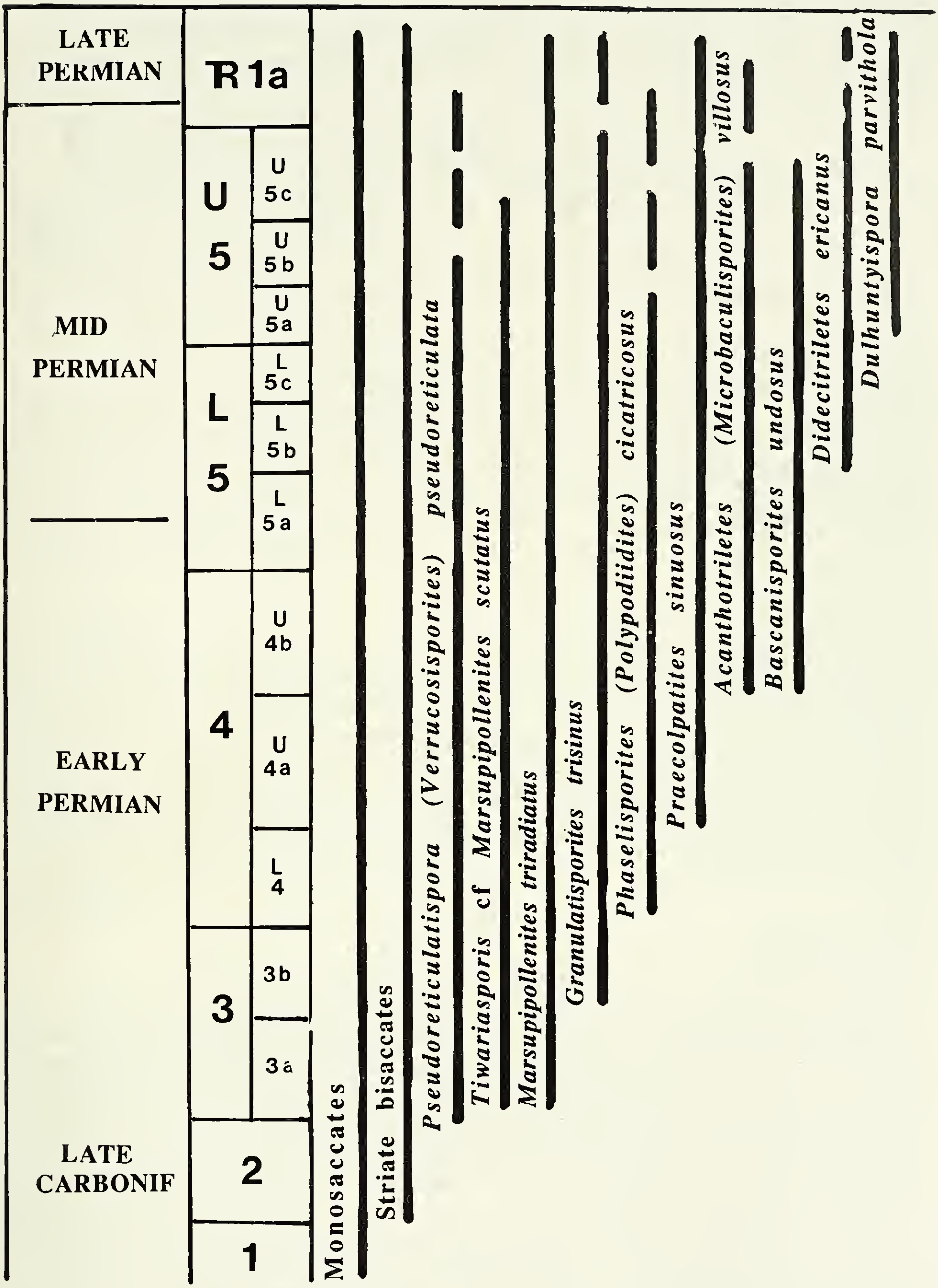

Fig. 2. The stratigraphic range of diagnostic Permian species, after Kemp et al. (1977) and Price (1982).

Bore 30232, 113.7-115.2 m (Table 1) Striate bisaccates (*Protohaploxypinus* spp., *Striatopodocarpidites* spp.) are diverse and abundant, suggesting the Mid Permian.

Monosaccates (*Barakarites* spp.; *Plicatipollenites* sp.) are present also. The diagnostic species *Acanthotriletes villosus*, *Bascanisporites undosus*, *Didecitriletes ericanus*, *Marsupipollenites triradiatus*, *Phaselisporites cicatricosus*, *Praecolpatites sinuosus*, *Granulatisporites trisinus*, *Tiwarisporites* cf. *M. scutatus* are present. *D. ericanus* indicates that this assemblage is Lower Stage 5b (Fig 2).

TABLE 1

Permian spores and pollen. Nomenclature follows Kemp et al. (1977), Foster (1979) and Price (1982)

	30232 *113.7-115.2 m*	*36433* *53.3-68.6 m*
Acanthotriletes (Microbaculisporites) villosus	+	
Alisporites australis		+
Alisporites sp.	+	
Apiculatisporis cornutus	+	
Bascanisporites undosus	+	
Barakarites rotatus	+	
Cyathidites australis	+	
Brevitriletes levis	+	
Didecitriletes ericanus	+	+
Dulhuntyispora parvithola		+
Granulatisporites micronodosus	+	
G. trisinus	+	+
Indotriradites splendens		+
Marsupipollenites triradiatus	+	+
Thymospora ipsviciensis		+
Osmundacidites senectus		+
Phaselisporites (Polypodiidites) cicatricosus	+	
Plicatipollenites gondwanensis	+	+
Praecolpatites sinuosus	+	
Protohaploxypinus limpidus	+	+
Protohaploxypinus spp	+	+
Pseudoreticulatispora (Verrucosisporites) pseudoreticulata		+
Tiwariasporis cf. *Marsupipollenites scutatus*	+	
Striatoabieites multistriatus	+	
Striatopodocarpidites cancallatus		+
S. fusus		+
S. rarus		+
Striatopodocarpidites spp.		+
Verrucosisporites trisectus		+
Striomonosaccites sp.		+

Bore 36433, 53.3-68.6 m (Table 1). Striate bisaccates are diverse and abundant, with a few monosaccates present, suggesting the Mid Permian. The diagnostic species *D. ericanus*, *G. trisinus*, *M. triradiatus*, *Pseudoreticulatispora pseudoreticulata* and *Dulhuntyispora parvithola* are present. *D. parvithola* indicates Upper Stage 5a (Fig 2).

Bore 36434, 111.2-112.8 m. Poor preservation and low spore/pollen content limit identification. *Granulatisporites trisinus* and *Acanthotriletes villosus* are prsent: the latter indicates at least Upper Stage 4b.

Another poor assemblage at 122 m in this bore has only *G. trisinus* as a diagnostic species, but the assemblage is too restricted for an accurate assessment.

Bore 36437 at 109 m has a poorly preserved assemblage. *D. ericanus* is present, indicating a maximum age of Lower Stage 5b.

Tertiary

All of the Tertiary assemblages have abundant Myrtaceae and/or Casuarinaceae. Araucariaceae and other gymnosperms are present, sometimes common. *Nothofagus* is absent or present in very low frequencies. These characteristics place them in the Late Tertiary. The top of the sequence may have an increase in Asteraceae/Poaceae, thought to be Late Pliocene/Pleistocene. Fig. 3 presents the Late Tertiary stratigraphic units from the Lachlan River Valley. The *Nothofagus* phase, if it can be identified, is an excellent stratigraphic marker horizon. Experience has shown that the frequencies of *Nothofagus* in the *Nothofagus* phase is extremely variable (Martin, 1987).

Fig. 4 presents the Late Tertiary sequence from the Namoi River Valley between Baan Baa and Boggabri. The 91-93 m level has a small amount of the *menziesii* and *fusca* types of *Nothofagus* and a high *Cyathea* and other fern spore content; features which identify the *Nothofagus* phase (Martin, 1987). Araucariaceae is the most abundant gymnosperm here also, but it also abundant at 67-72 m and 33-34 m. The top of the sequence has a slight increase in Poaceae and a large increase in Cyperaceae, the latter indicative of open vegetated swamps.

Fig. 5 presents the Late Tertiary sequence from Coxs Creek. The sequence is less clear. A small amount of the *menziesii* type of *Nothofagus* at 76-78 m may mark the *Nothofagus* phase, and there is a peak in Araucariaceae and *Cyathea*/other spores in this assemblage, similar to that in Bore 36004. The increase in Asteraceae and Poaceae at 65-66 and 62-64 m, however, is deeper than expected. Experience, however, has shown that the palynostratigraphy of the tributaries may be abbreviated or atypical when compared with that of the main valley. Casuarinaceae is particularly abundant in the deeper levels of the Coxs Creek sequence.

Pleistocene

Assemblages above 20 m (Fig 4) are almost certainly Pleistocene. *Tubulifloridites pleistocenicus*, *Polyporina granulata* and Asteraceae cf Liguliflorae (Martin, 1973a) are present and these are thought to be indicative of the Pleistocene (Knight and Martin, 1989). When compared with other Pleistocene assemblages, the Asteraceae/Poaceae content is low and that of Myrtaceae very high. Most of the Myrtaceae are eucalypts and the grains have a distinctly modern appearance about them. Surprisingly, there is a small amount of Araucariaceae, but such a quantity may have been transported a considerable distance, perhaps from the upper reaches of the catchment.

Fig 6 presents cross sections of the sediments and shows the relationships of the assemblages.

The Vegetation

There is a considerable rainforest element: all of the gymnosperms (Table 2) and some of the angiosperms (Table 3). There is also a substantial sclerophyllous element (Table 3). Some of the taxa may contain both of these elements, for example, Casuarinaceae contains both *Casuarina/Allocasuarina* of sclerophyllous vegetation, and possibly *Gymnostoma* of rainforests. The *Angophora*/bloodwood eucalypt type is identifiable, but some of the other eucalypt types cannot be distinguished from other taxa in the family. The Myrtaceae unidentified group is far larger than the *Angophora*/bloodwood type and probably contains a mixture of eucalypts, other sclerophyllous elements and rainforest taxa.

Araucariaceae would have been common at some times. *Podocarpus* is also relatively abundant and the other gymnosperms are infrequent. The angiosperm rainforest pollen types are found in low frequencies, but these types are insect/other animal pollinated, hence under-represented.

The sclerophyllous element includes a number of shrub/undershrub taxa. The herbaceous/open-vegetated swamp taxa are also diverse (Table 3).

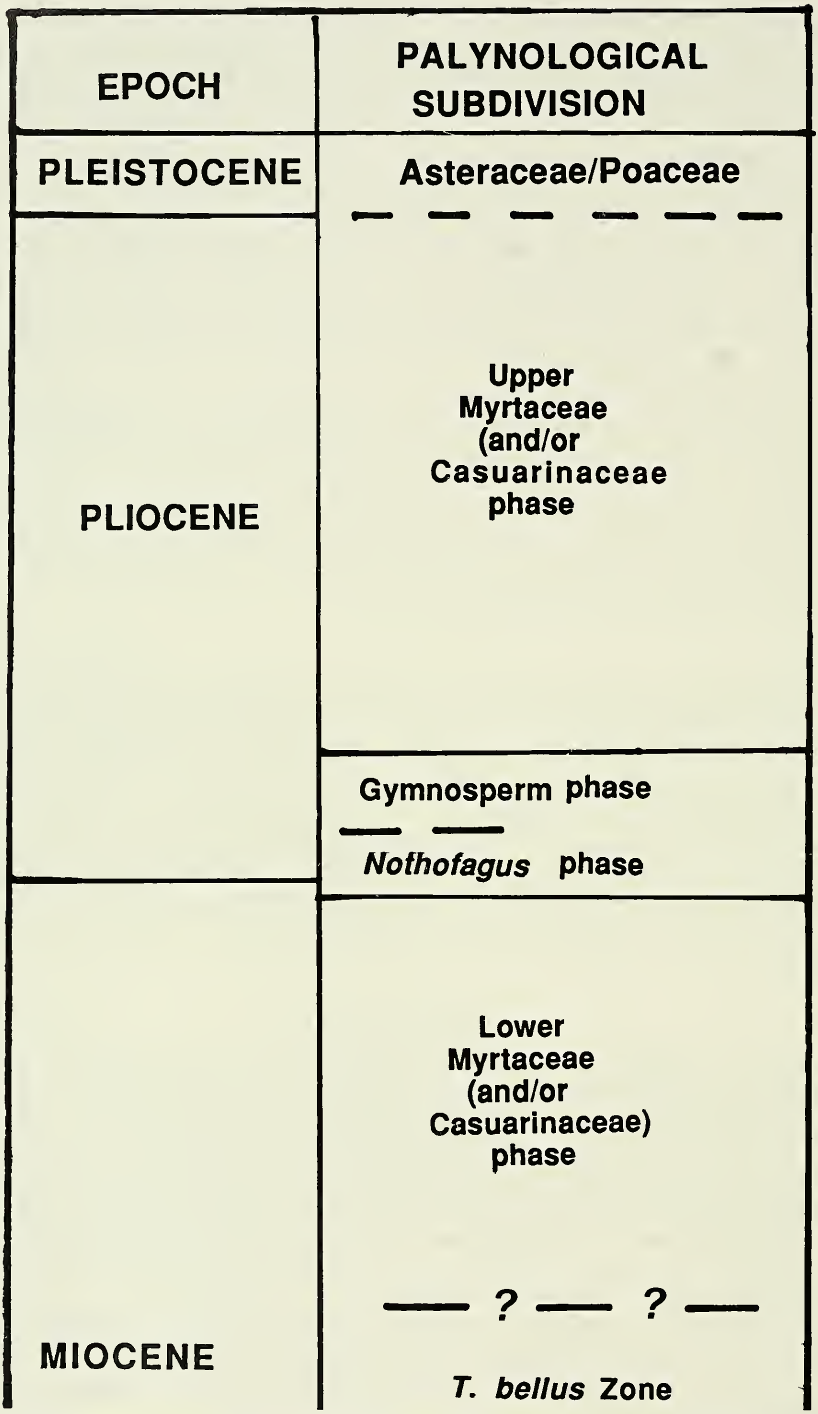

Fig. 3. Late Tertiary stratigraphic units of the Lachlan River Valley (from Martin, 1987). The *Nothofagus* in the Early Pliocene is the *menziesii* and *fusca* types only. The *brassii* type is not present. Note: Phase is used here for an informal subdivision.

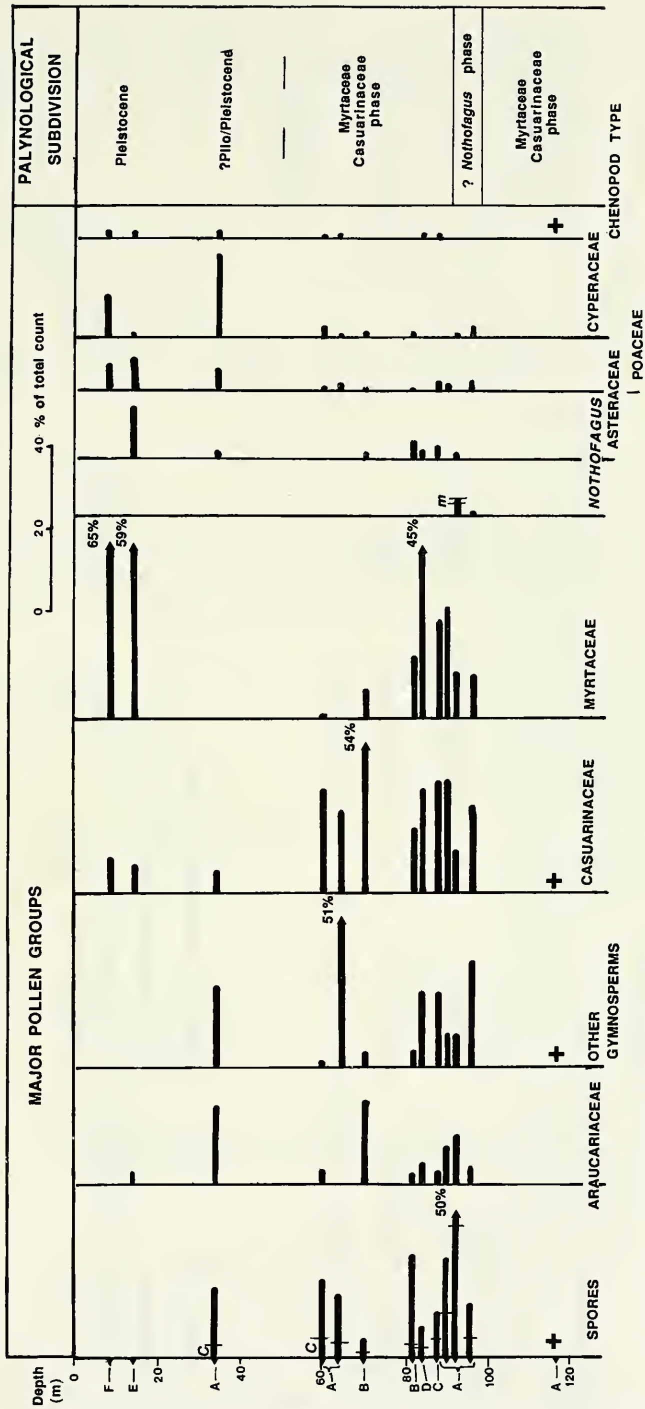

Fig. 4. Late Tertiary sequence from Baan Baa to Boggabri. Bores: A, 36004. B, 30232. C, 36185. D, 30050. E, 36057. F, 36182. For location of bores, see Fig. 1. For the species of gymnosperms, see Table 2. *C, Cyathea. m, menziesii; f, fusca* types of *Nothofagus*.

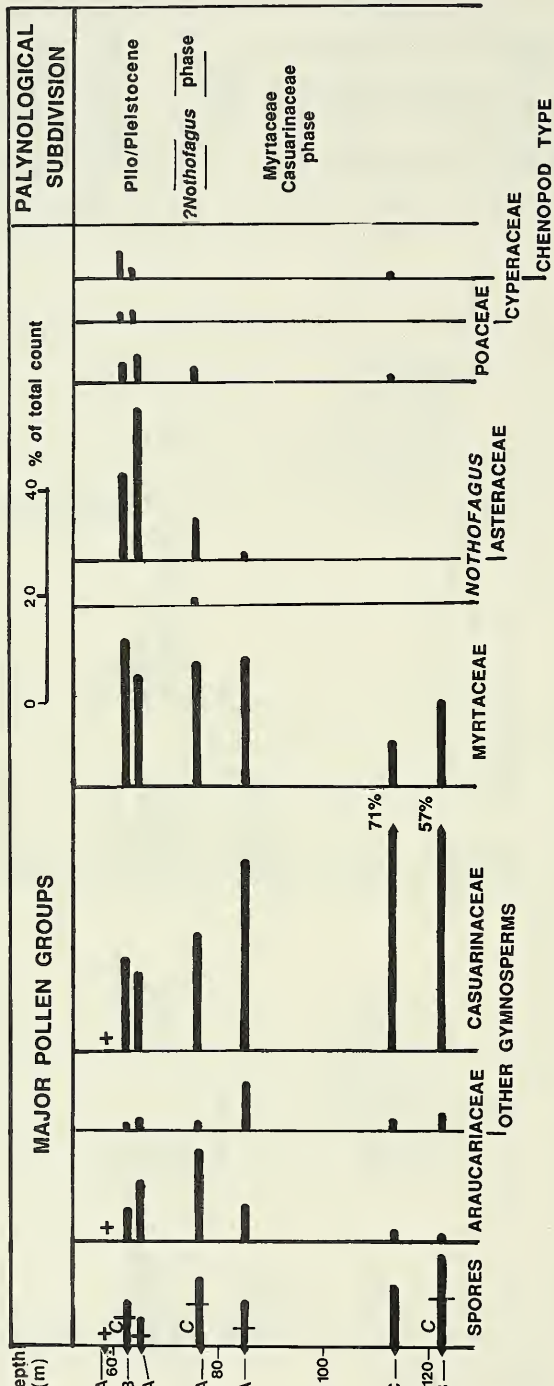

Fig. 5. Late Tertiary sequence from Coxs Creek. Cores: A, 36546. B, 36436. C, 36441. For location of bores see Fig 1. For species of gymnosperms, see Table 2. *C, Cyathea.*

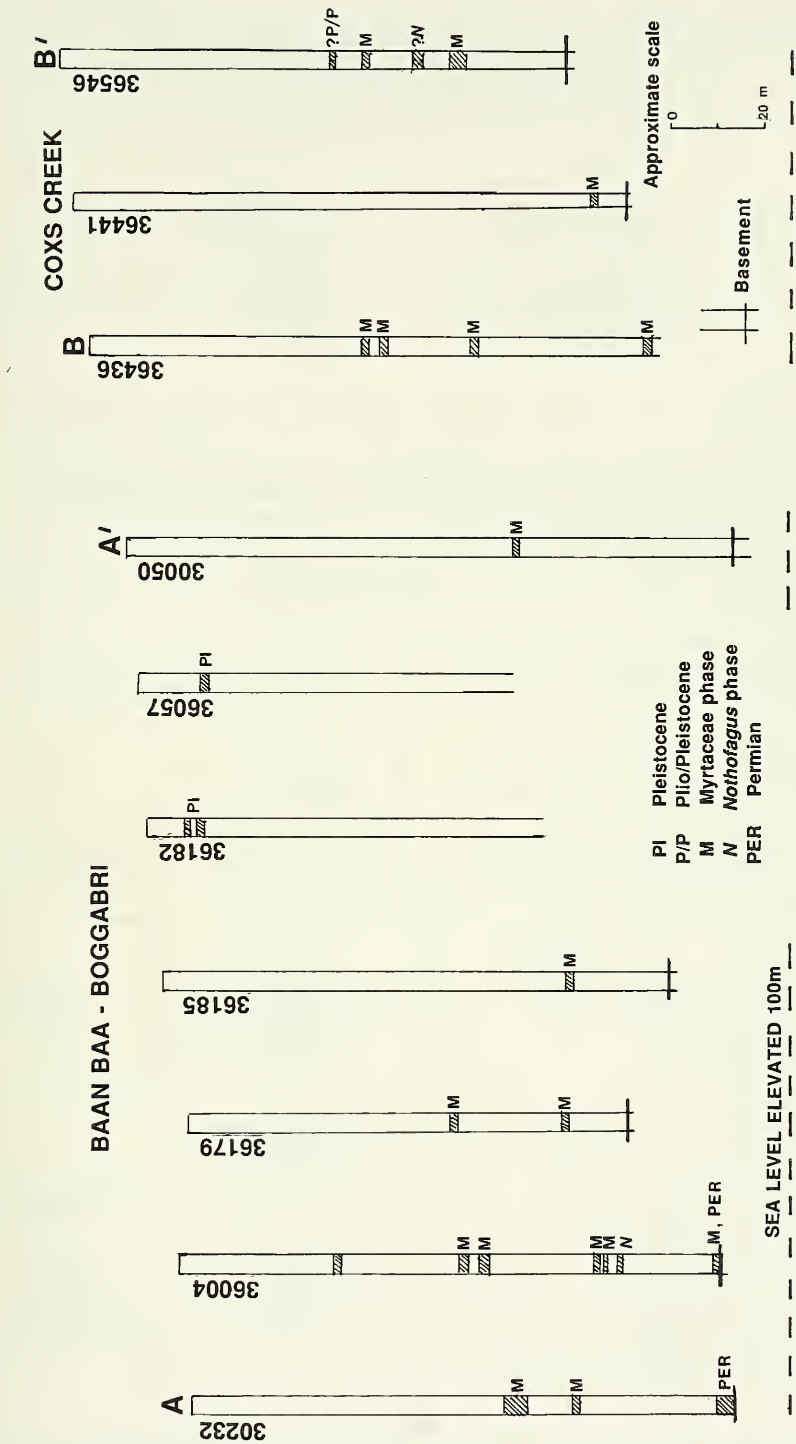

Fig. 6. Cross sections in the Namoi River Valley and Coxs Creek. For location of bores, see Fig. 1.

TABLE 2

The Late Tertiary gymnosperms. References to pollen types: 1, Martin (1973a). 2, Stover & Partridge (1973). 3, Cookson & Pike (1953a). 4, Cookson & Pike (1953b). 5, Cookson & Pike (1954a). For the distribution of the taxa, see Table 4.

Fossil Name	Botanical Name
Araucariacites australis 1	Araucariaceae
Cupressaceae 1	Cupressaceae
Dacrycarpites australiensis 1,3	*Dacrycarpus*
Lygistepollenites florinii 2,4	*Dacrydium*
Microcachryidites antarcticus 5	*Michrochacrys*
Phyllocladidites palaeogenicus 5	*Phyllocladus*
Podocarpidites spp 1	*Podocarpus*

TABLE 3

Low frequency angiosperms. Reference to pollen types: 1, Martin (1973a). 2. Stover & Partridge, (1973). 3, Cookson & Pike (1954b). 4, Truswell et al. (1985). 5, Martin (in press). 6, Martin (1978). 7, Pocknall & Cosby (1982). 8, Martin (1973b). R, rainforest; S, sclerophyll; H, herbaceous and open-vegetated swamp taxa. For the distribution of the taxa, sese Table 4.

Fossil Name	Botanical Name	
Acacia myriosporites 1	S	*Acacia*
Banksieaeidites elongatus 1	S	*Banksia*
Chenopodipollis chenopodiaceoides 1,4		Chenopodiaceae/Amaranthaceae
Cupanieidites orthoteichus 3	R	Cupanieae
Cyperaceae 1	H	Cyperaceae
Graminidites monoporites 1	H	Poaceae
Haloragacidites haloragoides 3	S	*Haloragis*
H. harrisii 2,3	S & ?R	Casuarinaceae
H. myriophylloides 3	H	*Myriophyllum*
Malvacearumpollis sp 4		Malvaceae
Micrantheum spinyspora 1	S	*Micrantheum*
Milfordia hypolaeniodes 1	S	Restionaceae
Milfordia sp	S	Restionaceae
Monotoca 5	S	*Monotoca*
Myrtaceidites eucalyptoides 3	S	*Angophora*/bloodwood eucalypt
Myrtaceae unidentified	R & S	Myrtaceae
Nothofagidites asperus 1	R	*Nothofagus menziesii* type
N. brachyspinulosus 1	R	*Nothofagus fusca* type
Polygonum sp 6	H	*Polygonum*
Polyporina granulata 1		?
Proteacidites ivanhoensis 1	R	*Helicia/Orites*
Proteaciaites sp	?S	Proteaceae
Quintinia psilatispora 1	R	*Quintinia*
Sparganiaceaepollenites barungensis 1	H	Sparganiaceae
Stephanocolpites oblatus 1		?
Tasmannia (Drimys) tetradites 1	R	*Tasmannia*
Tricolporites aveolatus 7		?
T. pelargoniodes 8	H	*Pelargonium*
Triporopollenites bellus 2,6	R	*Gardenia ('Randia') chartacea* type
Tubulifloridites antipodica/simplis 1	H	Asteraceae
Unidentified tricolpate/tricolporates		

The vegetation through the Late Miocene-Pliocene would have been a mosaic of rainforest with araucarians, and sclerophyll forests with eucalypts and/or *Casuarina/*

Allocasuarina dominent. The small amount of *Nothofagus* was probably transported from some distance, given the exponential decrease of pollen frequency with distance from source (Birks and Birks, 1980). It may have been growing in the upper reaches of the catchment. There would have been very little, if any, *Nothofagus* growing in the valley.

For the part of the Pleistocene represented here, eucalypt forests occupied the valley.

Discussion

The Tertiary palynostratigraphy of the Namoi Valley between Baan Baa and Boggabri (Fig 6) is remarkably similar to that of the Lachlan River Valley (Martin, 1987). Both have the *Nothofagus* Phase near the base of the Tertiary sequence, but not directly on the pre-Tertiary basement. The palynostratigraphy suggests that the rivers of the Western Slopes of the Great Divide have had a similar geological history (Martin, 1991).

Within this similarity of the sequences, the differences between assemblages of the two valleys are commensurate with what would be expected of the vegetation from the different geographic regions. *Nothofagus* is more prominent in the Lachlan River Valley (in the *Nothofagus* phase). Casuarinaceae may be abundant occasionally in the Lachlan, but assemblages with high frequencies are more common in the Namoi, particularly in Coxs Creek. Araucariaceae are frequently abundant in the Namoi region but not in the Lachlan. At Narrandera on the Murrumbidgee River, gymnosperms are more common immediately below the increase in Asteraceae/Poaceae and Araucariaceae may be the most abundant of the group (Martin, 1973b). Araucariaceae may be particularly abundant with the increase in Asteraceae/Poaceae in the Namoi, both in this region and in the Mooki Valley (Martin, 1979).

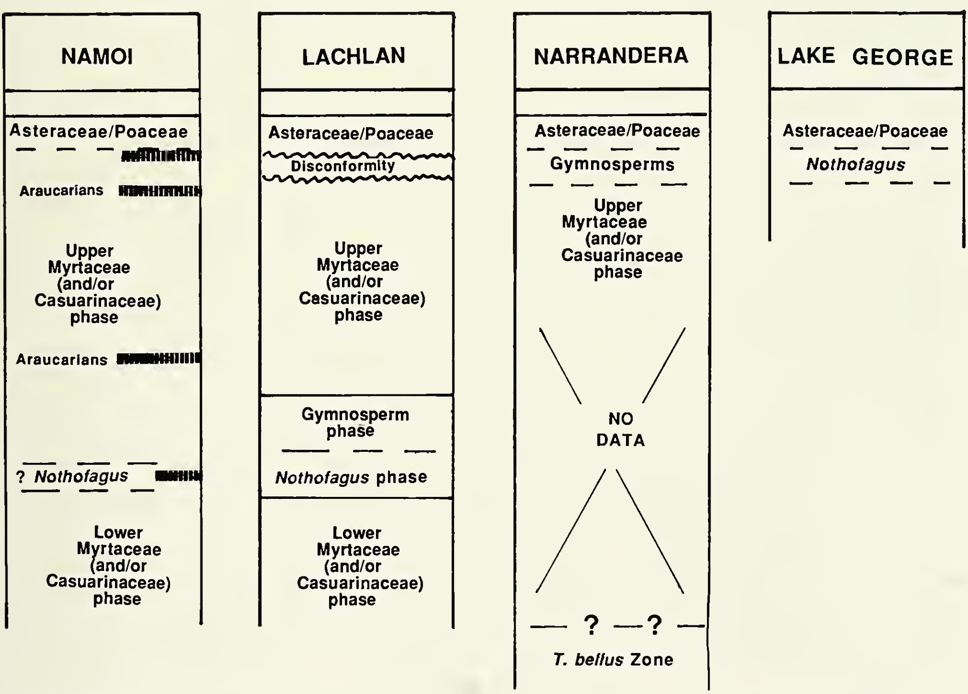

Fig. 7. Diagrammatic comparison of the stratigraphic sequence in Lake George, the Lachlan River Valley, Narrandera, and Namoi. Note: a large sand body, which does not yield pollen, occupies the position where the *Nothofagus* phase would be expected at Narrandera.

TABLE 4

The distribution of taxa potentially useful for stratigraphy, and regionally extinct taxa

Bore	36004						
Depth (m)	33-34	60-62	64-65	89-91	91-93	94-95	115-117
Araucariacites australis	•	•	•	•	•	•	•
Podocarpidites	•	•	•	•	•	•	
Dacrycarpites australiensis	•		•		•	•	
Phyllocladidites palaeogenicus	•				•	•	
Polyporina granulata	•						
Quintinia psilatispora		•				•	
Cingulatisporites bifurcatus		•		•		•	
Triporopollenites bellus		•					
Cupressaceae			•				
Lygistepollenites florinii			•		•		•
Cingulatisporites ornatus			•	•		•	•
Tricolporites pelargoniodes			•				
Microcachryidites antarcticus				•			
Tasmannia (Drimys) tetradites					•	•	•
Malvacearumpollis sp						•	
Micrantheum spinyspora						•	
Stephanocolpites oblatus						•	
Polygonum sp							•

Bore	36546				36441
Depth (m)	59-60	65-66	76-78	84-87	113-114
Araucariacites australis	•	•	•	•	•
Podocarpidites	•		•	•	•
Cingulatisporites bifurcatus	•	•	•	•	
Dacrycarpites australiensis		•		•	
Polyporina granulata		•	•		
Reticulatisporites echinatus		•	•	•	
Phyllocladidites palaeogenicus			•		
Stephanocolpites oblatus				•	
Monotoca				•	
Tricolporites alveolatus					•
Cupanieidites orthoteichus					•

Bore	30232		36186
Depth (m)	59-60	65-66	113-114
Araucariacites australis	•	•	•
Cupressaceae	•		
Podocarpidites	•	•	
Malvacearumpollis sp	•		
Cingulatisporites bifurcatus	•	•	
Phyllocladidites palaeogenicus		•	•
Tasmannia tetradites		•	•
Proteacidites ivanhoensis		•	•
Micrantheum spinyspora			•
Polygonum			•
Polyporina granulata			•

Bore	36436			
Depth (m)	59-61	62-64	82-84	121-123
Araucariacites australis	•	•	•	•
Cingulatisporites bifurcatus		•		
Polyporina granulata		•		
Cupressaceae		•		
Dacrycarpites australiensis				•
Lygistepollenites florinii				•
Podocarpidites				•
Tasmannia tetradites				•

This increase in abundance of Araucariaceae is not restricted to the *Nothofagus* phase and the base of the Asteraceae/Poaceae phase. It may be found sporadically in the upper Myrtaceae phase, in this study as well as in the Mooki (Martin, 1979) and Castlereagh (Martin, 1981) Valleys (Fig 6).

McEwen Mason (1989; 1991; Kershaw et al., 1991) found *Nothofagus* in sediments of Lake George, immediately below high Asteraceae/Poaceae, indicative of the Pleistocene. All three pollen types of *Nothofagus* are prsent, unlike the *Nothofagus* phase of the Lachlan River Valley where only the *fusca* and *menziesii* types are present. This occurrence of *Nothofagus* at Lake George has been dated by palaeomagnetics at approximately 2.8 million years (McEwen Mason, 1989). The *Nothofagus* phase of the Lachlan has not been dated by independent methods, but it cannot be the stratigraphic equivalent of *Nothofagus* at Lake George, as shown in Fig. 7. There is a long section of the upper Myrtaceae phase above the *Nothofagus* phase, and a disconformity below the high Asteraceae/Poaceae. It is likely that the stratigraphic equivalent of *Nothofagus* at Lake George is missing from the Lachlan, because of the disconformity. The Lake George *Nothofagus* may correlate with the gymnosperms (mainly *Podocarpus*) at Narrandera, the difference in the palynology being commensurate with the difference in the vegetation of these two regions. It may also correlate with araucarians in association with increasing Asteraceae/Poaceae in the Namoi, if the increase of Asteraceae/Poaceae is taken as a stratigraphic marker horizon in all of these geographic regions. All the evidence to date indicates that this increase is a reliable stratigraphic marker horizon (Martin, 1990).

The palynology of the river valleys of the Western Slopes shows that there was a surge of rainforest, thought to be Early Pliocene in age, as there is no means of independent dating (Martin, 1987). The study at Lake George (McEwen Mason, 1989; 1991) in the Highlands suggests that there was another surge of rainforest in the Late Pliocene, but the latter is not well expressed in the rivers of the Western Slopes. The nature of the rainforest varied considerably with the geographic region. It is possible that when the *brassii* type *Nothofagus* forests were found at Lake George, *Podocarpus* was common at Narrandera and araucarian forests flourished in the Namoi Valley.

The Pleistocene sequence here is too fragmentary to be placed more precisely. As interglacials were more forested/wooded and glacials more open/grassy/herbaceous, these Pleistocene eucalypt forests probably grew during one of the interglacials.

It has long been a mystery as to why only the *fusca* and *menziesii* types of *Nothofagus* are found in the Early Pliocene of the Western Slopes, when all three pollen types of *Nothofagus* are found together throughout the Early and Mid Tertiary. Read and Farquhar (1991) have experimented with living species from all three pollen types of *Nothofagus* and have found that the *brassii* type responds to a mild water deficit by closing its stomates, whereas the other two groups do not respond in this way. Read and Farquhar (1991) hypothesize that the *fusca and menziesii* types have evolved physiological and/or morphological mechanisms which allow the stomates to remain open at times of mild water deficit. While closed stomates may alleviate a moisture deficit, they inhibit carbon dioxide uptake, hence restrict photosynthesis. This behaviour of the *brassii* type is clearly a disadvantage if the climate becomes drier. The climate became progressively drier throughout the Late Tertiary (Martin, 1987), except for brief intervals when rainfall increased and allowed these surges of rainforest. Thus the progressively drier climate eliminated the *brassii* type first, but in highlands where the climate was wetter than the Western Slopes, it was persist for a longer time, until the Late Pliocene.

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